# CS/AM Internship: Using Machine Learning to Accelerate PDE solvers

Martin Schreiber (UGA/LJK)

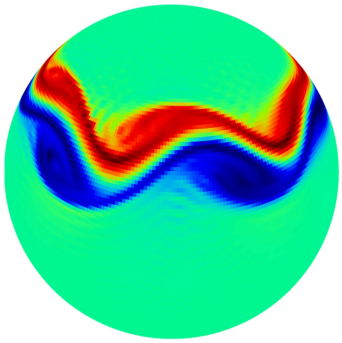
**Location:** Laboratoire Jean Kuntzmann, AIRSEA team, IMAG building, 700 avenue Centrale, 38401 Saint Martin d'Hères.

SWEET (`https://sweet.gitlabpages.inria.fr/sweet-www/`) is a PDE solver software that allows a fast exploration, investigation, and prototyping of time discretization methods for PDE solvers that use global spectral methods (Fourier for Cartesian systems & spherical harmonics on the sphere).

SWEET targets, in particular, to

- accelerate research around the development of (numerical) time integration methods
- investigate new ways to express parallelization
- do some early investigations of the scalability of novel time integration methods (e.g., parallel-in-time).

Since its beginning, it has been successfully used to steadily pioneer the research on parallel-in-time methods targeting climate/weather simulations by investigating time integration for the horizontal parts as part of shallow-water equations, see publications at `https://sweet.gitlabpages.inria.fr/sweet-www/publications/`.



Snapshot of a barotropic instability benchmark on the sphere computed with SWEET.

## 1 Goal

The overall goal is to **integrate machine learning models** as a another **time integrator** in SWEET.

## 2 Objectives

1. Objective "**SWEET**":
   Your first objective would be to make yourself familiar with the SWEET development. This will take a few weeks to understand how this solver infrastructure works and in particular how to add a new time integrator.
2. Objective "**Training data sets**":
   Based on simplified ODEs (and potentially also the 2D nonlinear shallow-water equations, which is relevant to weather/climate simulations), you will work in parallel on producing a variety of training and test data sets.
3. Objective "**Integration**":
   Since the generation of training/test data sets will take a while, you will work on integrating the possibility of evaluating machine learning models into SWEET (which is the main goal).

4. Objective "**Training**":
   After this process, you will train models to be used as a time integrator. Further details about the ideas behind this will be explained to you during the project.

5. Objective "**Results**":
   After the training, you will quantify the errors using ML for time integration.

## 3 Prerequisites

In order to ensure a successful internship for you and us, please ensure that you fulfill all or at least most of the following prerequisites. Please point out your qualifications in the application letter (see below).

- Very good understanding of neural-network-based ML
- Very good understanding of ODE and PDE solvers (Fourier analysis).
- Very good C++ programming skills (SWEET is written in C++).
- Ability to work independently (maybe previous experience in an internship/lab/etc.).

## 4 Application

To apply to this internship, send an Email to martin.schreiber@univ-grenoble-alpes.fr, including your CV, a transcript including all your grades (Bachelor + Master), and a brief explanation of why you are interested in this project.